Name Date

HANDS-ON LAB

Using Force to Test Materials

Sometimes the best material to do a job is too expensive or too difficult to obtain. In these situations, engineers look for a different material that performs similarly to the original material. The substitute material would have similar properties as the optimal material, but may be less expensive, easier to use, or easier to obtain.

In this lab, you will identify objects and materials that may be substituted for each other based on their strength. After brainstorming different ways to apply forces safely to each object or material, you will compare how they respond to a force over a range of magnitudes. Then you will assess how you might exchange one object or material for another in a design application. Keep in mind that the amount of material in an object and its shape may both affect its performance.

RESEARCH QUESTION How does an engineer determine the equivalent amount of each possible material needed in a design?

MAKE A CLAIM

Think about how to use the provided objects (coffee stirrers, craft sticks, burlap sack, etc.) in a specific situation. Select one object made of a different material to compare to a wooden craft stick. How many of this object would you need to substitute for one wooden craft stick? Explain your reasoning.

MATERIALS

- safety goggles
- coffee stirrers, plastic
- clamps
- hanging mass sets
- ring stand or other support
- ruler
- string
- wooden craft sticks

OPTIONAL MATERIALS TO BE TESTED

- baskets, wicker
- cans, aluminum
- coffee stirrers, bamboo
- corrugated cardboard strips
- egg cartons
- foam strips, soft
- foam strips, stiff
- plastic strips, flexible (from bendable plastic binders)
- metal strips (no lead)
- sack, burlap
- stockings, nylon

SAFETY INFORMATION

- Wear safety goggles during the setup, hands-on, and takedown segments of the activity.
- Use caution when using sharp tools or materials, which can cut or puncture skin.
- Immediately pick up any items dropped on the floor so they do not become a slip/fall hazard.
- Falling masses can cause injury. Place a box beneath your testing setup to catch and contain falling masses. Stand back from materials that might rupture, splinter, or send any kind of material flying outward when breaking.
- If a sample might be expected to fail during testing, develop and follow safety precautions. Testing plans should include safety precautions and be approved by your teacher before testing begins.
- Wash your hands with soap and water immediately after completing this activity.

CONDUCT RESEARCH

Use print and Internet resources to learn about compression, tension, and shear stress. Find out how materials engineers apply these stresses to test how different materials will behave when used in consumer or industrial products. Summarize what you learn in your Evidence Notebook.

PLAN THE INVESTIGATION

1. In your Evidence Notebook, develop a procedure to test the strength of different objects or materials. Follow these guidelines as you plan:
   - Design a method to measure the deformation and recovery of a sample. Each lab team will test wooden craft sticks so that you may compare testing strategies and outcomes at the end of the lab. Choose at least two additional objects or materials to test, including the one referenced in your predictions.
   - Evaluate the range of force magnitudes needed to observe deformation in each structure. Choose a way to stress each sample by compressing, stretching, or applying a shear force to it. For example, you might clamp a sample at each end, then hang or place masses on the object between the clamps for a bend test. This test provides compression where the mass is in contact with the sample and tension (stretch) on either side.
   - Determine which variables or factors you will control or keep the same between tests of different samples. This testing practice allows a valid comparison of results between tests.
   - Perform a test run to check that your testing plan will work. Revise your testing strategy as needed.
   - Consider what might happen if a sample suddenly snaps. Take steps to ensure the safety of yourself and the people and property around you.
2. Construct a data table to record your observations and measurements. Include columns for the name of the object or material, the direction of force, responses to force, and upper-force limit. The upper-force limit refers to the amount of force the structure can withstand before deformation is permanent.
3. Have your teacher approve your plan and safety precautions before proceeding.

COLLECT DATA

With your teacher's approval, follow the steps in your procedure. Perform your investigation as planned and note any issues or new ideas that emerge during the investigation. Making changes to your testing procedure as you go is expected and important. Consult with your teacher about any changes to your inquiry strategy.

ANALYZE

1. **Patterns** Compare the objects and materials and their relative strengths, paying attention both to the amount of material and the shape of each sample. Can you identify any patterns in the performances of the samples?

2. Were the performances limited by the way you chose to test the samples? If you changed your testing procedures, would you obtain different results?

3. **Use Mathematics** How strong is one wooden craft stick in comparison to a single unit of another sample that you tested? Explain your reasoning using evidence and mathematics. Describe how the other sample that you tested deformed in comparison to the wooden craft stick.

CONSTRUCT AN EXPLANATION

1. **Engage in Argument from Evidence** Identify your strongest sample. Identify another sample and explain how many of the second sample you would need in order to provide the same strength as your strongest sample in a design application. Use evidence from your investigation to support your answer.

2. Suppose you wanted to support a force outside the range of your tests. Do you have enough evidence to choose a sample and determine how much you would need? If so, explain how you would make the choice and determination. If not, explain what investigation you would perform in order to get the evidence you need.

DRAW CONCLUSIONS

Write a conclusion that addresses each of the points below.

Claim How many of your chosen structure would you need to substitute for one wooden craft stick in a design application? Did your investigation confirm your predictions?

Evidence What evidence from your investigation supports your claims?

Reasoning Explain how the evidence you gave supports your claims. Describe in detail the connections between the evidence you cited and the argument you are making.

EXTEND

1. How could you use the results of your investigation to solve a real-world problem? Explain a possible problem, then describe how your experimental results might help you design a solution to the problem.

2. Did your investigation lead you to have more questions? What other tests are you inspired to perform, given your results? Why?